DARWIN AS A BOTANIST.

By Lester F. Ward.

Appointed by the committee to furnish a brief sketch on this occasion of the contributions of Charles Darwin to the science of plants, I have purposely chosen the title, "Darwin as a Botanist," in order to emphasize the contrast which may be drawn between different classes of botanists, and to do what I can to accustom the public mind to associate with the terms *botanist* and *botany* certain great fields of investigation which are now rarely suggested by these words.

If I had entitled my paper: Darwin's researches into the phenomena of the vegetable kingdom, I fear it might not have occurred to some of you that this great investigator was a botanist, as he is not generally known as such. Yet I fail to see why the science of botany is not fully entitled to receive its share of the dignity and the luster which Darwin's investigations have reflected upon biology in general.

The popular idea of botany, however, is very different from this. Not ignorant people alone, but scientific men as well, place all botanists under two general classes: "Field Botanists" and "Closet Botanists."

The field botanist is one who, being passionately fond of plants and having mastered the rudiments of botany and become familiar with the names and classification of plants, searches the country for new and rare species, and for new localities for old ones, and makes large collections. Success in these objects is his triumph, and occasionally becoming the proud discoverer of hitherto unknown forms of vegetable life, he finds the scientific world quick and generous in awarding him due credit.

The closet botanist is one who, disdaining the boyish pursuit of flowers, devotes himself to the study of the characters of plants as revealed by the herbarium specimens which the field botanist so

copiously furnishes, and by which method he, too, can discover "new species," and obtain prompt recognition. The closet botanist performs the further useful service of "revising" intricate families and genera of plants, unraveling the entanglements of previous authors, and making such changes in the classification and names as are best suited to secure the maximum personal credit.

I need not tell this audience that Charles Darwin belonged to neither of these classes of botanists. A lover of nature, he yet never wasted precious time in the idle pursuit of rarities. Thoroughly familiar with the distinctive characters upon which botanical classification rests, he yet never pursued to any marked extent the investigation of specimens from the *hortus siccus*. I doubt whether a single species of plant was ever named after him by reason of his having either discovered it in a wild state or detected its specific distinct ness by the examination of its characters. I even doubt whether he possessed an herbarium, in the accepted sense of the word.

And yet this man has probably contributed more to our real knowledge of plants than any other single botanist.

In what, then, have Darwin's botanical investigations consisted?

There is a little French book entitled "Voyage d'un Botaniste dans sa Maison," a title which, allowing for the characteristic hyperbole of the French tongue, suggests the general nature of Darwin's botanical studies. His researches were conducted in his laboratory, in pots of plants at his window, in his aquarium, in his green-house, in his garden. He worked with instruments of precision, recorded his observations with exactness, and employed every mechanical device for making his results reveal important truths, of which the genius of man would seem to be capable.

Darwin looked upon plants as *living things*. He did not study their *forms* so much as their *actions*. He interrogated them to learn what they were *doing*.

The central truth, towards which his botanical investigations constantly tended, was that of the universal *activity* of the vegetable

kingdom—that all plants *move* and *act*. He has, so to speak, *animated* the vegetable world. He has shown that whichever kingdom of organic nature we contemplate, to *live* is to *move*.

He blandly rebukes the vulgar notion that "plants are distinguished from animals by not having the power of movement," and still more modestly says that "plants acquire and display this power only when it is of some advantage to them." But is this the whole? Do animals display this power except when it is of some advantage to them? Certainly not.

Darwin shows us that certain parts of all plants are at all times in motion; not merely the molecular activities of their tissues and of the living protoplasm in their cells, but organized movement of parts. Every leaf, every tendril, every rootlet, possesses the power of spontaneous movement, and under nearly all circumstances actually exercises that power.

There are a great many distinct kinds of movement, depending in all cases upon the special advantages thereby gained to the plant. The laws under which these movements take place have received from him an admirable terminology. Most of them are conditioned either by light, by gravity, by radiation, or by insect agency.

We thus have of the first class, *heliotropism*, or movement towards the light; *apheliotropism*, or movement from the light; *diaheliotropism*, or movement at right angles to the source of light; and *paraheliotropism*, embracing such movements as screen the plant from excess of light.

To the second class belong: *geotropism*, or movement towards the earth or into the soil; *apogeotropism*, or movement contrary to the force of gravity; and *diageotropism*, or movement at right angles to the force of gravity.

The third class embraces the so-called *nyctotropic* movements of plants by which they appear to sleep, and which prove to be devices for the prevention of excessive radiation of the plants' heat.

Under the fourth class fall all those wonderful movements which aid the plant in preventing self-and securing cross-fertilization, a

subject of the most absorbing interest, and of which you have already listened to so able a presentation by Prof. Riley from the point of view of the entomologist.

But Darwin's great service has been to show that these varieties of activity are simply modes in which inherent and spontaneous activities manifest themselves under these varying external influences.

His preliminary investigations into the nature of these innate powers of movement were directed to that large class of plants known as twiners and climbers, whose revolving motions were so thoroughly described in his work on "Climbing Plants." It was here that he laid the foundation for those later studies which eventually resulted in that great work, almost his last, on the "Power of Movement in Plants." In this work he demonstrates by an enormous induction that the ample sweeps of the twining plant are but the most obvious manifestations of a class of phenomena which are common to the entire vegetable kingdom.

Amid the varied forms of movement which plants present Darwin has succeeded in finding one fundamental and generic one to which every other may be referred. To this universal form of plant activity he gives the name "circumnutation." Not only twining stems and tendrils, but parts of flowers, tips of growing shoots, caps of penetrating roots and rootlets, radicles, epicotyls, cotyledons, and even full-grown leaves, are incessantly describing circles, ellipses, and other more or less regular geometrical figures; and he conclusively shows that it is out of this primary form of activity that all the more specialized forms already mentioned have been developed. All movements of the parts of plants are thus to be interpreted as modified forms of this innate periodic circumnutation which is common to all plant life. Such modifications are always in the direction of the plant's advantage and may be so great as to become difficult of recognition as forms circumnutation.

I need not labor to convince you that any modification which is an advantage to the plant will be secured by the process of natural selection. It is the glory of the great genius whose labors we are

here to commemorate to have demonstrated this truth to the entire satisfaction of the united scientific world.

Darwin has actually solved the great problem of phytology, so long supposed to be incapable of solution, viz: Why does the root grow downward and the stem upward? Briefly and roughly stated, the answer to this question is that, as the bursting seed pushes out its two germinal points these circumnutate from the first, and thus explore their surroundings for the means of benefiting the plant. To employ Darwin's own word, they "perceive" the advantage that would result from the penetration of the soil, on the one hand, and from the ascent into the free air and sunlight, on the other, and through the pre-Darwinian law of the "physiological division of labor," the one becomes *geotropic* and the other *heliotropic* —the one develops into a radicle and then into a root, while the other develops into an epicotyl and then into a stem.

I will only add to the thoughts already presented that Darwin's discovery of the existence in all plants of an innate and spontaneous mobility belonging to them as forms of organic life, possesses an important ulterior significance.

The law of natural selection, as a fundamental process, has long since passed the stage of discussion. But there has always remained one unsettled question lying at its very base which Darwin himself admitted to be an open one. That question concerns the cause itself of variation. It is granted that, admitting the *tendency to vary*, all the results claimed for natural selection must follow; but many declare that, in this very tendency to vary, there is a mystery as great as the mystery of life itself.

It is only in this work on the "Power of Movement in Plants" that Darwin has really assailed this last fortress of supernaturalism. Not that he has avowed any such purpose, for of this he would have been incapable, but so skilfully and so powerfully has he marshaled the facts that the conclusion follows without being stated. No one can doubt that he perceived this, and I, for one, am convinced that he saw it from afar, and that it was the great end of his labors;

but with his characteristic wisdom he has declined to invoke the *odium theologicum*, correctly judging that the truth must ultimately assert itself.

The tendency to vary, then, is a mechanical result of the proved fact of universal movement coupled with the admitted law of natural selection. By means of the former all plants and growing parts of plants are perpetually exploring their immediate surroundings in search, as it were, for conditions favorable to development. By means of the latter they are able to avail themselves of such favorable conditions when found. Nothing further than this is required to complete the natural explanation of all the phenomena presented by the organic world, and thus, at last, the whole domain of biology is emancipated from teleological fetters, and placed on the high plane of rational investigation.

In conclusion, let me simply say that, while we can but deeply mourn the irreparable loss which science has sustained in the death of Charles Darwin, we have still the highest grounds for congratulation in the fact that he lived to complete that great work which, next to the "Origin of Species," will, I firmly believe, be awarded by posterity the highest place, viz. ,"The Power of Movement in Plants;" for, while the former auspiciously opened the great debate by stating the profoundest of all biological problems, the latter has fittingly closed the argument by answering the last objection.